by the tide or waves, there is no evidence of their voluntarily leaving the water to bask or feed on the shore.

The species now existing are very few, and there is reason to believe that the time is not far distant when they will all become extinct. One species, the *Rytina stelleri*, or Northern Sea-cow, an animal attaining nearly the length of thirty feet, by far the largest known member of the order, from the North Pacific, was totally exterminated by the agency of man during the last century, and the surviving species, the Manatis and Dugongs, being valuable for their flesh as food, their hides, and especially for the oil obtained from the thick layer of fat which lies immediately beneath their skin, rapidly diminish in numbers as civilised populations occupy the regions which form their natural habitat.

The Manatis (genus *Manatus*), found on the Atlantic coasts of America and Africa, are rather fluviatile than marine in their habitat, ascending large rivers almost to their sources, and feeding chiefly on aquatic grasses. The Dugongs (genus *Halicore*) are more distinctly marine, feeding chiefly on algæ. They inhabit the shallow waters, bays and creeks of various coasts of the Indian Ocean, the Red Sea, East Coast of Africa, the Indo-Malayan Archipelago, and north coast of Australia. There is probably not more than one species, but they have been divided into three according to the locality which they inhabit. *H. tabernaculi* from the Red Sea, *H. dugong* from the Indian Seas, and *H. australis* from Australia. These two existing genera present such well-marked distinguishing characters that if they alone were known they might be placed in separate families, but as in so many similar cases our knowledge of the extinct forms, imperfect as it is, goes far to bridge over the distinction between them. It is true that Brandt, a great authority on this group, divides the order into two primary sections—*Manatidæ*, consisting of *Manatus* alone, and *Halicoridæ*, containing all the other genera; but it scarcely seems that these can be considered in any sense as equivalent, especially as one of the distinguishing chracters, the external form of the tail is unknown in the extinct genera.

The Miocene and early Pliocene seas of Europe abounded in Sirenians, to which the generic name *Halitherium*, Kaup, has been given. They had large tusk-like incisors in the upper jaw, as in the existing *Halicore*, though not so greatly developed. Their molar teeth are $\frac{5}{5}$ or $\frac{6}{6}$, anteriorly simple and single-rooted, posteriorly with three roots in the upper jaw, and two below, and with enamelled, tuberculated, or ridged crowns, in which respect they approach nearer to *Manatus*, the molar teeth of the Dugongs being without enamel and single-rooted. The anterior molars were deciduous. Some species, at least had nasal bones, short, broad, but normal in position, whereas in all the existing genera these bones are quite rudimentary. Another and still more important evidence of conformity to the general mammalian type is the better development of the pelvic bone, and the presence of a small styliform femur articulated to the acetabulum, although no traces of any other part of the limb have been discovered. These ancient Sirenians were thus, in dental, cranial, and other osteological characters, less specialised than are either of the existing species, and if the intermediate links could be discovered, might well be looked upon as ancestral forms from which the latter have been derived, but at present the transitional conditions have not been detected. As far as we know, when changes in the physical conditions in the European seas rendered them unfitted to be the habitation of Sirenians, the Halitherium type still prevailed. If the existing Dugongs and Manatis are descended from them, their evolution must have taken place during the Pliocene and Pleistocene epochs, the one in seas to the east, the other to the west of the African continent, which has formed a barrier to their intercommunication. Halitherium remains have been found in many parts of Germany, especially near Darmstadt, in France, Italy, Belgium, Malta, the Isthmus of Suez, &c. Until lately none were known in our own country, probably owing to the absence of the beds of an age corresponding to those in which they are found on the Continent; but quite recently a skull and several teeth have been detected among the rolled *débris* of Miocene formations, out of which the Red Crag of Suffolk is partially composed. The species are not yet satisfactorily characterised. Some of them appear to have attained a larger size than the existing Manati or Dugong. One of these from the Pliocene of Italy and France, having but $\frac{5}{5}$ molar teeth, has been separated generically under the name of *Felsinotherium* by Capellini, by whom it has been fully described. A portion of a skull found in Belgium has been named *Crassitherium*, by Van Beneden, and some compressed teeth, somewhat similar to, but larger than those of the Dugong, discovered in the department of Lot et Garonne, France, have given origin to the genus *Rytiodus* of E. Lartet. *Pachyacanthus* of Brandt, from the Vienna basin, is also, according to Van Beneden, another form of Sirenian, of which, however, the skull is not known. In various Miocene and perhaps Eocene marine formations of the United States of America, remains of Sirenians have been discovered, but mostly in such a fragmentary condition that they afford at present little evidence of the early history of the group in that country. A more satisfactory discovery is that of a nearly complete skull and some bones from a limestone tertiary formation in Jamaica. It is of smaller size than the Manati, and as far as the teeth are concerned, of a still more generalised character than Halitherium, the dentition being apparently

$$i\,\frac{3}{3}\,c\,\frac{1}{1}\,p\,\frac{5}{5}\,m\,\frac{3}{3}=48.$$

The incisors are small, not developed into tusks, the canines (wanting in all existing Sirenians) are rather longer than the incisors, judging by the sockets, and the molars are bilophodent, and covered with enamel. It has been described by Prof. Owen under the name of *Prorastomus sirenoides*. Unfortunately we have no knowledge of the geological antiquity of the formation in which it was embedded. Lastly must be mentioned the *Eotherium egyptiacum*, Owen, founded on the cast of a brain, with a small quantity of surrounding bone, discovered in the Nummulitic limestone of Eocene age of the Mokattam Hills, near Cairo. The brain is narrower than that of *Manatus*, and resembles *Halitherium*. This is of interest, as the most ancient known evidence of any Sirenian, whose age has been geologically determined.

The few facts we have as yet been able to collect of the former history of the Sirenians leave us as much in the dark as to the origin and affinities of this peculiar group of animals as we were when we only knew the living members. They lend no countenance to their association with Cetacea, and, on the other hand, their supposed affinity with the Ungulata, so much favoured by modern zoologists, receives no very material support. The assumption lately put forth with so much confidence that the Sirenia are the remains of a group of animals, through which the Cetacea passed in their evolution from terrestrial Mammalia, is quite without foundation.

(*To be continued.*)

PROF. HUXLEY'S LECTURES ON THE EVIDENCE AS TO THE ORIGIN OF EXISTING VERTEBRATE ANIMALS[1]

II.

It was seen in the last lecture that no ultimate answer was obtainable as to the origin of the examples selected from the fish class, any more than is afforded as

[1] A course of six lectures to working men, delivered in the theatre of the Royal School of Mines. Lecture II., March 6. Continued from p. 389.

to the origin of the Anglo-Saxons by showing that they came from Friesland in the sixth or seventh century. The same remark applies to the origin of nearly all fishes, in fact, only one clear case of progressive modification is known in the whole class; this is afforded by the group of the *Pycnodonta*.

These are fish not unlike our John Dory in shape, which appear for the first time in the carboniferous rocks, and become extinct in the older tertiaries; they are distinguished by the possession of rows of large crushing teeth, and in place of a vertebral column had a gelatinous *chorda dorsalis* or *notochord*. The spinal cord above this was embraced by arches of bone, placed at regular intervals along the chorda; and, immediately below these neural arches, were attached the ribs, also bony. In the Carboniferous forms, both arches and ribs are quite distinct from one another, and are simply united by ligamentous fibres to the notochord; but, in the older Secondary species, they become expanded at their ends, and thus tend to embrace the notochord; and, lastly, in the Tertiary pycnodonts this process is carried to such an extent as almost to produce a ring of bone, like the body of a rudimentary vertebra.

Now let us turn to the next group of Vertebrate animals, that of Amphibia (frogs, toads, newts, and salamanders), which are distinguished from fishes by certain very striking peculiarities. Fishes are all capable of breathing the air dissolved in water by means of gills, and—a far more important distinctive character—their limbs always have the character of *fins*, which organs are seen in their simplest form in Ceratodus. In this fish, there is a long jointed cartilaginous axis, running down the middle of the fin, with rows of rays of the same substance on each side of it; the whole is invested by a fold of the integument, the margins of which are beset with horny filaments called fin-rays. In all fishes these elements are to be found, generally in a curiously modified condition; in the bony fishes, for instance, the central axis with its side appendages are broadened out and shortened, the fin-rays becoming at the same time so much larger as to form the main part of the fin.

Some modification of this type of limb is possessed by all fishes which have limbs at all; but the first character, that afforded by the respiratory organs, is not absolute, for there are some fishes which, besides gills, possess an apparatus for breathing air directly. This apparatus, represented by the air-bladder of ordinary fishes, first takes on its new character and becomes a lung in that remarkable genus, Ceratodus, in which it exists as a large cellular structure situated in the upper part of the abdominal cavity, just under the vertebral column, and connected with the gullet by a slit—the glottis—by means of which the fish can pass air from the mouth into the lung. It is not, however, this peculiarity of opening into the œsophagus which constitutes a lung, for the air-bladder of many fishes possesses an open duct of a similar nature; the great distinguishing feature is, that the blood taken to this bladder does not pass into the ordinary venous channels, but is returned immediately to the heart, in a purified condition, by a special vein. In Ceratodus there is no special vessel to carry blood *to* the lung, in other words, although there is a pulmonary *vein*, the pulmonary *artery* has not appeared; but in the Mudfish (Lepidosiren) of Africa and eastern South America, the development of the lung goes a step further, a special pulmonary artery being present, as in all the higher animals. Thus Ceratodus and Lepidosiren are truly *amphibious*, for they can be suffocated neither by removal from water like most fish, nor by immersion in water like the higher animals.

What constitutes the difference between these amphibious fish, and the lowest of the true Amphibia? Not the nature of the respiratory process, for many of the latter group, such as the blind Proteus of the Austrian caves and the North American Menobranchus possess gills throughout life, but the structure of the limbs, which are now, no longer *fins*, but *legs*. A fish requires a broad surface for balancing itself in the water, locomotion being chiefly performed by the tail, but in land animals an apparatus is required capable of raising the body above the ground, and the limbs take on the form of a set of jointed levers. In its simplest form the higher vertebrate limb consists, first, of a single piece of cartilage articulated with the body, then two pieces side by side, then a number of small nodules, and lastly, five series of short jointed pieces; all of these become in the adult state more or less converted into bone. The first or proximal division of the limb is called the humerus in the fore limb, the femur in the hind limb; the next segment consists of radius and ulna in the arm, tibia and fibula in the leg; the nodular pieces are respectively carpals and tarsals, and the series of jointed bones or cartilages, the five digits. From the lowest Amphibia upwards, the limbs, when present, are always constructed upon this type.

Nevertheless, the Amphibia still retain certain fish-like characters, which are lost in the groups above them. They all, at some period of life, breathe by means of gills, although all have, in the adult state, lungs in addition. Some forms, such as the Proteus and Menobranchus mentioned above, retain their gills throughout life and are hence called *Perennibranchiates;* others, such as Menopoma, Amphiuma, &c., lose them in adult life, and are called *Caducibranchiates*. These two last genera, however, still retain traces of gill-clefts, but in all the Amphibia with which we are acquainted in this country, the frog, toad, and newt, even the clefts disappear, and the perfect air-breathing character is assumed.

These animals, in the course of their development, go through a very singular series of metamorphoses, comparable to those by which a grub is converted into a butterfly. At this season of the year, every pond is almost certain to contain frog-spawn, masses of transparent albuminous matter, with numberless imbedded eggs, consisting of yolk, black on one side and white on the other. A few hours after these eggs are laid, the process of development begins by the formation of a shallow groove, which appears quickly on the black, more slowly on the white hemisphere, and is just such a groove as would be produced by drawing a blunt instrument along the equator of a soft globe. The egg is thus divided into two masses. A second form appears at right angles to the first, dividing the whole egg into four; others appear, in definite order, cutting it up into smaller and smaller masses, until the whole yolk becomes granular, or formed of microscopic *cells*. Two ridges then appear, on the surface of the egg, and, uniting in the middle line, inclose a cavity, the lining membrane of which is converted into the brain and spinal cord. The head gradually becomes differentiated, and the mouth appears on its under side; the tail grows out, and the little creature, getting too long for the egg, becomes coiled upon itself, and, before long, ruptures the egg-membrane, and makes its exit from its mass of jelly.

It is now, to all intents and purposes, a fish; it has no limbs, its mouth is provided with horny jaws, and it breathes by means of a pair of plumose gills. It further differs from the adult frog in being herbivorous, feeding on water plants, to which it attaches itself by means of two suckers near the mouth. The tadpole grows rapidly, and, before long, a fold of skin appears on each side, which gradually closes over the gills, leaving, however, for a considerable time, a small opening on the left side. In the meantime the limbs appear, and the lungs are developed, the tadpole breathing for a time both by lungs and gills; the latter eventually disappear, the tail shortens, the limbs lengthen, the horny jaws are replaced by teeth, and an insect-eating tail-less frog is formed, the adult air-breathing form having thus been attained by a wonderful

series of changes, in which the fish, Lepidosiren, perennibranchiate, and triton, are all represented.

One would be inclined to infer from these metamorphoses, that, on tracing the Amphibia back in time, the story of their origin should be told, but, as a matter of fact, palæontological history tells a different story altogether. Abundant remains of frogs and toads are found in the Miocene deposits, some of which are of so fine a character that even the tadpoles are preserved; but these tertiary frogs and toads do not differ, in any important particulars, from those of the present day, and the same is true of the tritons and salamanders. Some of the latter attained a very great size, and one of them—a near ally of the great Japanese salamander of the present day—has had a very singular fate, having been described, about the middle of the last century, as a fossil man, by the German naturalist Scheuchzer, who named it "Homo diluvii testis," the man who saw the flood!

In the Wealden and Purbeck formations no Amphibia have as yet been discovered, but, from the Lower Lias to the Carboniferous they turn up again in remarkable numbers, and of great size, but differing from existing forms in some important peculiarities, and affording no help whatever to our inquiries as to the origin of the existing or of the tertiary frogs, toads, and salamanders. Under the throat, these gigantic Amphibia had a remarkable shield of three bony plates, as well as a series of plates along the belly. Their teeth were large and powerful, and presented an extremely complicated structure, whence the group has received its name of *Labyrinthodonta*.

Thus, in tracing back the existing Amphibia, we find a great break in the secondary period, and then come upon a distinct group, the Labyrinthodonta, from which the existing forms cannot possibly be deduced. These, again, have been traced no farther back than the carboniferous epoch.

(*To be continued.*)

PHYSICAL SCIENCE IN SCHOOLS

THE beginning of a discussion on any great subject elicits mainly differences of opinion; its end should be to establish agreement as to principles, and in great measure as to details. The first half of this dictum has been illustrated by the interesting letters in your columns on Physical Science in Schools; its entire confirmation as the correspondence proceeds will confer on education a benefit of the most timely kind.

The moment is a critical one for scientific teaching. Lord Salisbury's Bill will come to mean a revolution in the educational structure of the Universities; the Report of the Science Commission proposes to re-cast the teaching of the schools; public feeling, unexpressed as yet on other points, is distinct in wishing to see Science heartily recognised and systematically taught. If Science Teachers will agree as to what they want and press it vigorously, the game is in their hands.

I venture to lay down for consideration in NATURE certain propositions on this subject in the hope that they, or such others as may be preferred to them, may become the basis of the agreement we all desiderate:—

1. The business of a school is general education; the business of a University is special education.

2. The principal subjects taught at a school should be Literature, Mathematics, Science.

3. Each of these subjects should be studied in fixed relative proportions of time, from the very beginning of a school course until its close.

4. Scholarships offered for any one of these subjects to the exclusion of the others at the entrance on University life are mischievous in their effect on school teaching, and ought to change their character or be abolished.

5. Science should be taught to every boy in a school for at least six hours in the week; holding a fair place in Entrance Examinations, being encumbered with no pecuniary charges unimposed on other subjects, and having a value in school-marks proportional to the time spent upon it.

Of these five theses, the first three and the fifth are in exact harmony with the recommendations of the Science Commission; the fourth follows necessarily from the others, as stigmatising a system whose continuance makes general school teaching impossible, and whose significance gains point from the curious admission of one of your correspondents as to the intellectual cost of a Balliol Scholarship.

The feasibility of teaching science to the youngest schoolboys, assumed in what I have said, demands a word of comment. The evidence on this point scattered through the Report of the Commission, and partly summarised in Report VI., pp. 6—9, is, if not overwhelming, so strong as to outweigh many-fold anything that has yet been said against it. I desire to advance with humility, but with great earnestness, my own experience, extending over fourteen years, in support of the view there laid down; and Mr. West's admirable letter in NATURE, vol. xiii., p. 48, represents, as I well know, the conclusions of many successful teachers. If grammatical analysis and arithmetical numeration are taught every day to boys of nine years old, why not the elements of science? It were well surely to inquire what parts of this vast subject and what treatment of them have been found suitable to younger minds; for the statement on the part of any individual that science cannot be taught to little boys means nothing more than that he himself has failed to teach it.

My object in writing is a practical one. I have stated the principles which seem to me to underlie all school science teaching worthy of the name, and I invoke a judgment upon them, possibly a reversal of them, at the hands of experienced teachers. If it be true, as we were lately told, that the head-masters are awaiting instruction from the public, let us prepare the public to educate their illustrious pupils. At any rate, let scientific men be ready to answer the appeal which will be made to them when the Report of the Science Commission comes before the House of Commons, with such unanimity as only abundant and unprejudiced discussion can generate. To let slip this opportunity will be to find, I fear, with the Jew of Malta, that "Occasion 's bald behind."

W. TUCKWELL

I notice in your columns that a discussion has been conducted for some time past on that important subject, Physical Science in School Teaching. Permit me, as one possessing a deep practical interest in this matter, and also as a science teacher of some years' experience, to remark that in Scotland, generally, and in this great educational centre in particular, the chief obstacle which stands in the way of extended science teaching, is the simple apathy of educationalists to the claims of scientific instruction. It were well that, before disagreeing as to the exact mode of teaching, the claims of one science over another, and other points, science teachers should thoroughly agree as to the necessity for more openly enforcing their claims upon the notice of those who sit in high places in the world of educational management. I gladly welcomed an opportunity afforded me by the Edinburgh branch of the "Educational Institute of Scotland," in December last, to address the members of the Institute, consisting in the main of teachers of all subjects, on the "Place, Method, and Advantages of Biological Instruction in Ordinary Education." The substance of that address will shortly appear in *Fraser's Magazine*, and to that medium I would respectfully refer those of your readers who are interested in this question, for a *résumé* of a science teacher's work and method in the northern metropolis. I would fain hope that the argu-